WHAT IS CLAIMED IS:

1. A method of classifying specimens based on X-ray data obtained from such specimens, the method comprising:

providing X-ray data from a plurality of known specimens having known characteristics which are classified into a plurality of known classes;

setting up a pattern recognition process to automatically classify the known characteristics of the known specimens based on the X-ray data from the known specimens;

providing X-ray data from an unknown specimen having an unknown characteristic of an unknown class; and

utilizing the pattern recognition process to automatically classify the unknown characteristic of the unknown specimen based on the X-ray data from the unknown specimen.

2. A method as recited in claim 1, wherein providing the X-ray data from the known specimens comprises:

directing a charged particle beam toward each known specimen; and

detecting X-rays emitted from the each known specimen in response to the charged particle beam, wherein the detected X-rays form X-ray data having one or more intensity values at one or more energy levels.

3. A method as recited in claim 2, wherein providing the X-ray data from the unknown specimen comprises:

directing a charged particle beam toward the unknown specimen; and

detecting X-rays emitted from the unknown specimen in response to the charged particle beam, wherein the detected X-rays form X-ray data having one or more intensity values at one or more energy levels.

4.   A method as recited in claim 1, wherein the unknown specimens and the known specimen are each a semiconductor device or test structure.

5.   A method as recited in claim 1, wherein the known and the unknown characteristic are each a defect and the known classes are known defect classes.

6.   A method as recited in claim 5, wherein the known defect classes include defect compositions.

7.   A method as recited in claim 5, wherein each known defect class includes one or more characteristics selected from a group consisting of a particular defect composition, a defect location, an electrical type defect, and an open type defect.

8.   A method as recited in claim 5, wherein each known defect class includes a particular film thickness.

9.   A method as recited in claim 1, wherein setting up the pattern recognition process comprises:

training a pattern recognition process to recognize particular types of X-ray data as belonging to one of the known classes.

10.   A method as recited in claim 9, wherein the pattern recognition process is selected from a group consisting of a neural net algorithm, a natural grouping algorithm, and a wavelet algorithm.

11.   A method as recited in claim 1, wherein setting up the pattern recognition process comprises:

associating a feature vector having a plurality of parameters with each known specimen based on the each know specimen's X-ray data;

selecting a set of weight values for each variable in a class code equation;

inputting the selected weight values and the parameters of each feature vector into the class code equation to determine a plurality of class codes for the known specimens;

adjusting the weight values until the class codes for the known specimens having a same known class result in a same class code value; and

storing the weight values and class code values for the known specimens.

12.   A method as recited in claim 11, wherein utilizing the pattern recognition process to automatically classify the unknown characteristic of the unknown specimen based on the X-ray data from the unknown specimen comprises:

associating a feature vector having a plurality of parameters with the unknown specimen;

inputting the stored weight values and the parameters of the feature vector of the unknown specimen into the class code equation to determine a class codes for the unknown specimen;

comparing the class code for the unknown specimen to the stored class codes for the known specimens; and

when the class code for the unknown specimen matches a one of the stored class codes, classifying the unknown specimen based on the matching class code.

13.   A method as recited in claim 12, wherein utilizing the pattern recognition process to automatically classify the unknown characteristic of the unknown specimen based on the X-ray data from the unknown specimen further comprises:

when the class code for the unknown specimen does not match a one of the stored class codes, defining a new class code based on the X-ray data from the unknown specimen.

14.   A method as recited in claim 12, wherein the parameters of each feature vector of the known specimens and the unknown specimen include intensity values for each X-ray peak and its associated energy level and/or one or more ratios of X-ray intensity values.

15.   A method as recited in claim 14, wherein the parameters of each feature vector of the known specimens and the unknown specimen further include a defect size.

16.   An apparatus for classifying specimens based on X-ray data obtained from such specimens, comprising:

a beam generator operable to direct a charged particle beam towards a specimen;

a detector positioned to detect X-rays from the specimen in response to the charged particle beam; and

a processor operable to:

provide X-ray data from a plurality of known specimens having known characteristics which are classified into a plurality of known classes;

set up a pattern recognition process to automatically classify the known characteristics of the known specimens based on the X-ray data from the known specimens;

provide X-ray data from an unknown specimen having an unknown characteristic of an unknown class; and

utilize the pattern recognition process to automatically classify the unknown characteristic of the unknown specimen based on the X-ray data from the unknown specimen.

17. An apparatus as recited in claim 16, wherein providing the X-ray data from the known specimens comprises:

directing a charged particle beam toward each known specimen; and

detecting X-rays emitted from the each known specimen in response to the charged particle beam, wherein the detected X-rays form X-ray data having one or more intensity values at one or more energy levels.

18. An apparatus as recited in claim 17, wherein providing the X-ray data from the unknown specimen comprises:

directing a charged particle beam toward the unknown specimen; and

detecting X-rays emitted from the unknown specimen in response to the charged particle beam, wherein the detected X-rays form X-ray data having one or more intensity values at one or more energy levels.

19. An apparatus as recited in claim 16, wherein the unknown specimens and the known specimen are each a semiconductor device or test structure.

20.   An apparatus as recited in claim 16, wherein the known and the unknown characteristic are each a defect and the known classes are known defect classes.

21.   An apparatus as recited in claim 20, wherein the known defect classes include defect compositions.

22.   An apparatus as recited in claim 16, wherein setting up the pattern recognition process comprises:

training a pattern recognition process to recognize particular types of X-ray data as belonging to one of the known classes.

23.   An apparatus as recited in claim 22, wherein the pattern recognition process is selected from a group consisting of a neural net algorithm, a natural grouping algorithm, and a wavelet algorithm.

24.   An apparatus as recited in claim 16, wherein setting up the pattern recognition process comprises:

associating a feature vector having a plurality of parameters with each known specimen based on the each know specimen's X-ray data;

selecting a set of weight values for each variable in a class code equation;

inputting the selected weight values and the parameters of each feature vector into the class code equation to determine a plurality of class codes for the known specimens;

adjusting the weight values until the class codes for the known specimens having a same known class result in a same class code value; and

storing the weight values and class code values for the known specimens.

25. An apparatus as recited in claim 24, wherein utilizing the pattern recognition process to automatically classify the unknown characteristic of the unknown specimen based on the X-ray data from the unknown specimen comprises:

associating a feature vector having a plurality of parameters with the unknown specimen;

inputting the stored weight values and the parameters of the feature vector of the unknown specimen into the class code equation to determine a class codes for the unknown specimen;

comparing the class code for the unknown specimen to the stored class codes for the known specimens; and

when the class code for the unknown specimen matches a one of the stored class codes, classifying the unknown specimen based on the matching class code.

26. An apparatus as recited in claim 25, wherein utilizing the pattern recognition process to automatically classify the unknown characteristic of the unknown specimen based on the X-ray data from the unknown specimen further comprises:

when the class code for the unknown specimen does not match a one of the stored class codes, defining a new class code based on the X-ray data from the unknown specimen.

27. An apparatus as recited in claim 25, wherein the parameters of each feature vector of the known specimens and the unknown specimen include intensity values for each X-ray peak and its associated energy level and/or one or more ratios of X-ray intensity values.